Utilization of Oat Flour as Edible Coating Material on Fried Chicken Meat Balls

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Abstract

Wheat flour (W) and Corn flour (C) were substituted with oat flour (O) by 3:1, 1:1, and 1:3 rations in battering and breading processes to investigate the effect on some properties of coated-fried chicken meat balls. Batter and bread formulations without O addition were used as control, and all samples were fried for 5 min at 180 ^oC. Adhesion degree and yield values increased, while frying loss value decreased by increasing level of O in the batter mixes. Samples coated with 3:1 W: O mix in batters provided the highest moisture and the lowest oil content after frying. Moreover, increasing O in batter mixes increased *a* and *b* values of fried samples. The addition of O in breading mixes positively affected sensory properties such as appearance, colour, and taste, while it had no effect on battering mixes. Results of the study showed that O can be successfully used as a coating material on chicken meatballs.

Keywords

Oat Flour; Wheat Flour; Corn Flour; Edible Coating; Chicken Meat Ball

Introduction

Chicken meat is an extremely sensitive food compared with other commodities during storage and cooking processes. Therefore, its producers traditionally focus on new preservation and cooking techniques (Gennadios et al. 1997; Maskat & Kerr, 2004).

Moisture loss and decrease in sensorial properties are serial problems that affect consumer preferences. However, increasing the fat content of fried food during frying can also cause coronary heart diseases and obesity in humans. Researchers try to solve these problems and use different coating materials on food in the procedures of fried food (Brincic et al. 2004; Kilincceker & Hepsag, 2012)

Coating processes that use different materials such as gums, proteins, or cereal flours improve the characteristics of such foods. Edible coatings enhance food flavour, texture appearance and act as a barrier against fat absorption and moisture loss by protecting the natural juices of food during the frying process; thus, the final product has a tender and juicy structure and an appropriate colour (Kulp & Loewe, 1990; Nasiri et al. 2010; Kılınççeker, 2011).

Coatings are performed as battering and breading on the foods. Generally, meat and other foods are dipped in liquid solutions (this is called *battering*), and they are covered with dry coating materials (this is *breading*). The type, amount, and physical and chemical properties of raw materials in these processes have significant effects on the coated product (Kulp and Loewe, 1990; Kilincceker & Hepsag, 2012).

Corn, wheat, and oat flours have different properties and are economically viable in the global market. They have high protein and starch ratios. Thus, the functional properties of these flours are very important in food products. However, the coating studies conducted on oat flour are few, while the coating studies about corn and wheat flour are too many (Kulp and Loewe, 1990; Selehifar & Shahedi, 2007).

Oat flour can be considered an alternative as a coating material compared with wheat and corn flour. On an average, oat flour contains about 14% protein, 64% starch, and a significant amount of crude fiber, vitamins, and minerals. Especially, it has more protein and golden-yellow colour compared with wheat and corn flour. It does not contain any anti-nutritional or toxic factor. Protein content and colour pigments correlate with the physical and chemical characteristics of batters and breads. Also, they affect the properties of the coated and fried product (Selehifar & Shahedi, 2007; Nunez et al. 2009).

Due to these properties of oat flour, it can be used as an interesting source of raw materials for coated chicken meat. The application of an appropriate amount of this flour can exhibit beneficial effects in the coating process. The use of oat flour in coating processes can increase viscosity and adhesion degree of batters and pick up of breading materials on meat

balls. It can decrease shrinkage and drying of chicken meat balls during frying, decrease mass transfer from chicken meats, and enhance sensorial properties as the colour and texture.

The aim of this study is to determine the effect of different composite coatings from oat flour and other flours (wheat flour and corn flour) on the quality of chicken meat balls.

TABLE 1 BATTER AND BREAD FORMULAS

Batters (100 ml)	Breads
30 g W + 1 g salt + 1 g baking powder + distilled water (Control)	99% C + 1% salt (Control)
30 g 3:1 W:O + 1 g salt + 1 g baking powder + distilled water	99% 3:1 C:O + 1% salt
30 g 1:1 W:O + 1 g salt + 1 g baking powder + distilled water	99% 1:1 C:O + 1% salt
30 g 1:3 W:O + 1 g salt + 1 g baking powder + distilled water	99% 1:3 C:O + 1% salt

W: wheat flour, O: oat flour, C: corn flour

Materials and Methods

Materials

In this study, chicken breasts of same age, wheat flour (W), corn flour (C), and other ingredients were obtained from a local market in Adıyaman. Oat flour (O) was purchased from Smart Chemical Co. (İzmir, Turkey). Corn oil was used as the frying medium (Yudum, Yudum Co., Balıkesir, Turkey). A mini fryer (Arzum, AR 246) that has a thermostatic heat control was used for carrying out frying operations.

Methods

Fresh chicken breasts were minced using a mincing machine. The minced meat was used to prepare the meat ball batter according to the following receipt:

88% minced meat + 10% bread crumbs + 0.5% onion powder + 0.5 % garlic powder + 1 % salt

Then, chicken meat balls were prepared as 30 mm diameter and 16 ±1 g weight. They were dipped in batter for 30 s, as shown in Table 1, and allowed to drain for 1 min. Subsequently, each sample was coated with an equal amount of breading material for 15 s (Table 1) and fried at 180 ±1 ^{o}C for 5 min. Totally, fourteen chicken balls were used during all of the analysis for each sample.

The moisture rate of the flours was gravimetrically determined by oven drying at 105 ±1 ^{o}C for 4–6 h. The protein rate of the flours was measured using the Kjeldahl method (AACC, 1995).

Adhesion degree, yield, and frying loss values were carried out by measuring the mass of the raw chicken meat balls (X), the mass of the coated chicken meat balls before frying (Y), and the mass of the coated chicken meat balls after frying (Z); calculations were as follows:

$$\text{Adhesion degree} = \left(\frac{Y-X}{Y}\right)x100, \quad \text{Yield} = \left(\frac{Z}{X}\right)x100,$$

$$\text{Frying loss} = \left(\frac{Y-Z}{Y}\right)x100$$

A standard penetrometer (Yüksel Kaya Mechanics, Turkey) was used to measure the hardness of the fried chicken meat balls at the end of the 2 min of frying. The penetrometer needle had a 56.2-g load. It was left to free fall from the same distance for each sample. The penetration depth was read as the mm after 3 s of penetration.

The moisture in the fried samples was detected at 105 ±1 ^{o}C for 6–8 h, and the oil content was identified by using the soxhlet extraction method (AOAC, 2000).

Color was measured in three fried samples from each of the coating treatments. The measurement of *L* (lightness), *a* (redness), and *b* (yellowness) values was performed on the surface of coated chicken meat balls using an instrument (Minolta CR-400, Osaka, Japan) at the end of 2 min of frying. The instrument was standardized against a white standardization plate before each measurement.

Ten semi-trained judges and a hedonic scale were used to conduct scores of organoleptic evaluations (appearance, color, odor, taste, and texture). The average score of these parameters be deemed to the overall acceptability. The different scores on the scale indicated the following values: 1: extremely dislike; 2: dislike very much; 3: moderately dislike; 4: slightly dislike; 5: neutral; 6: slightly like; 7: moderately like; 8: like very much; 9: extremely like (Gökalp et al. 1999).

In a statistical analysis, the experimental design of the randomized factorial model (4x4) contained four types of battering and four types of breading. The work was done as the two replications and battering and breading formulations with no oat flour addition were used as the control samples. The data were evaluated by a variance analysis, and results were expressed as mean ± standard deviation. In case of differences among the samples, the differences were compared by Duncan's multiple-range test at the level of $p < 0.05$ using a statistical analysis system program (SPSS, Chicago, IL, USA).

TABLE 2 SOME PHYSICAL AND CHEMICAL PROPERTIES OF FLOURS IN COATING PROCESSES

Flour	<0.125mm	>0.25 mm	Moisture (%)	Protein (%)	Starch (%)
W	72.42	2.99	12.68	9.96	69.01
O	0.70	80.29	7.65	11.28	35.04
C	2.45	51.47	12.70	6.28	68.85

W: wheat flour, O: oat flour, C: corn flour

TABLE 3 EFFECTS OF COATING MATERIALS ON ADHESION, YIELD, FRYING LOSS AND PENETROMETER VALUES OF CHICKEN MEAT BALLS

Coatings	Adhesion (%)	Yield (%)	Frying loss (%)	Penetrometer values (mm)
Battering				
Control	11.06±0.84 ^{c}	98.42±1.05 ^{c}	12.48±0.55 ^{a}	20.88±4.24 ^{a}
3:1 W:O	10.07±0.59 ^{c}	97.22±1.11 ^{d}	12.58±0.53 ^{a}	22.07±5.76 ^{a}
1:1 W:O	12.16±1.01 ^{b}	100.26±1.24 ^{b}	11.94±0.76 ^{ab}	23.16±5.92 ^{a}
1:3 W:O	15.54±1.50 ^{a}	104.25±1.21 ^{a}	11.13±1.53 ^{b}	21.87±4.40 ^{a}
Breading				
Control	11.96±1.93 ^{a}	100.68±3.62 ^{a}	11.27±1.55 ^{c}	21.98±7.37 ^{a}
3:1 C:O	12.25±1.98 ^{a}	100.10±2.75 ^{a}	12.21±0.79 ^{ab}	23.52±2.87 ^{a}
1:1 C:O	12.79±2.96 ^{a}	100.30±2.68 ^{a}	11.93±0.72 ^{ab}	22.02±3.98 ^{a}
1:3 C:O	11.83±2.65 ^{a}	99.06±2.88 ^{a}	12.71±0.48 ^{a}	20.47±4.97 ^{a}

W: wheat flour, O: oat flour, C: corn flour, The alphabets a, b and c in superscripts are the statistical differences among the samples.

Results and Discussion

Some Properties of Flours

Some physical and chemical properties of coating materials affect the quality criteria of coatings and coated food. Especially particle size, moisture, protein, and starch rate of raw materials are important factors for coating processes. They affect the viscosity and adhesion degree of batters and breads. Therefore, they affect the moisture loss, oil absorption, and texture of coated products during frying. Particle size, moisture, protein, and starch values of flours are shown in Table 2. As depicted in the table, the highest particle size is at O; the lowest moisture rate and the highest protein are 7.65% and 11.28%, respectively, in oat flour. In addition, although it didn't contain as much as W and C, O had very high degree of starch (Table 2).

Adhesion, Yield, Frying Loss and Penetrometer Values of Coated Chicken Meat Balls

During battering, the effects of flour mixes on adhesion degree and frying yield were found to be significant at the level of $p < 0.01$. However, they had effect on frying loss at the level of $p < 0.05$. During breading, flour mixes affected the frying losses only significantly ($p < 0.05$). Adhesion and yield values increased by increasing oat flour in battering mixes. However, frying loss values decreased by increasing oat flour in battering mixes (Table 3). The highest adhesion and yield values (15.54% and 104.25%) were determined in samples coated with a 1:3 W: O mix in batter coatings. The lowest frying losses were also found in samples coated with 1:1 W: O and 1:3 W: O mixes as 11.94% and 11.13% in battering applications. Frying loss values increased, while the amount of oat

flour in breading mixes increased, unlike battering (Table 3). The lowest frying loss in a control sample was 11.27%. Penetrometer values were in the ranges of 20.88–23.16 mm for battering and 20.47–23.52 mm for breading processes. However, coating materials did not have a significant effect on these values ($p > 0.05$).

Batters formed an adhesive and a homogeneous surface on chicken meat balls and increased the pick-up of breading on this surface. Moreover, batters whose content (high level) of O were more viscous and adhesive than batters of W. O had a higher protein level and lower moisture content than did W and C. In battering applications, O adhered on the chicken meat surface, degraded during the frying process, and provided a barrier that inhibits the mass loss from the chicken meat balls. Thus, O increased the adhesion degree and yield while decreasing frying loss. However, increases in frying loss values along with increases in the amount of O in breading applications were connected with a loss of coarse particles in O during frying. While they provided weight and visual interest, they had small surface areas.

These particles and excessive weight caused particle breakage during frying (Dyson, 1990; Maskat & Kerr, 2004). Mass transfer from the chicken meat to the outside increased during deep frying, which was also suggested by Kilincceker and Kurt (2011) and Kilincceker (2011). In several studies, to provide better coating properties, such as adhesion and texture properties, various flours were used. They contain proteins and polysaccharides. These materials create more adhesive properties to coatings and a high yield on food (Nasiri et al. 2010; Kilincceker &Hepsag, 2012). Kulp and Loewe (1990) reported that by increasing the protein rate of coating material, adhesion degree and yield significantly increase while frying loss decrease. Similarly, our study revealed that a high adhesion and yield can be achieved by using O as a battering material.

Moisture and Oil Contents of Fried Chicken Meat Balls

In the variance analysis conducted on the moisture and oil contents of fried samples, it was determined that the effects of flour mixes in battering were significant ($p < 0.01$), while the effects of flour mixes in breading were not significant ($p > 0.05$).

Generally, the moisture content in fried samples decreased by increasing the oat flour in battering (Fig. 1). Unlike moisture, oil rates in fried samples increased, while the amount of oat flour in batter increased. The highest moisture and the lowest oil content were determined in samples coated with 3:1 W: O mix. After breading, moisture and oil rates in fried chicken meatballs were found to be in the range of 54.63–55.12% and 6.34–6.37%, respectively (Fig. 1).

There is a linear relationship between water loss and oil uptake. Protein and carbohydrate contents and types of coating materials affect them. O has a very low amount of gluten in its protein profile compared with W. While the amount of O increased, the amount of gluten decreased in battering mixes. The structure formed by gluten offered more resistance against the mass transfers of other protein types in flours. Although the amount of protein in batter mix increases, water loss and oil absorption during frying may be increased due to the effects of gluten decrease in batters. Because, the structures of coats which formed on chicken meat balls during frying were not resistance against the water and oil transfer. In addition, the oil content that is available in O might naturally increase oil values of fried samples after frying. However, O has higher oil content than W (Selehifar & Shahedi, 2007; Brewer, 2012).

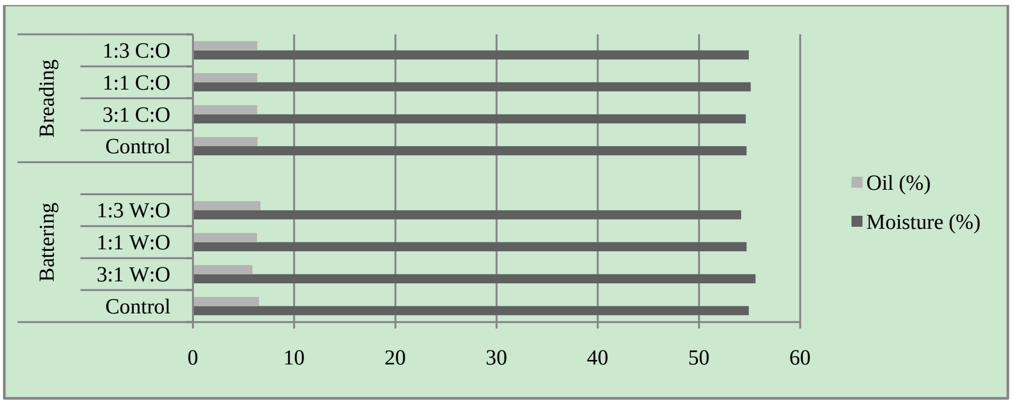

FIG. 1 EFFECTS OF COATING MATERIALS ON MOISTURE AND OIL CONTENTS OF FRIED CHICKEN MEAT BALLS

TABLE 4 EFFECTS OF COATING MATERIALS ON COLOR VALUES OF FRIED CHICKEN MEAT BALLS

Coatings	*L*	*a*	*b*
Battering			
Control	52.78±3.66 [a]	8.25±1.84 [b]	19.74±0.62 [b]
3:1 W:O	51.94±1.84 [ab]	7.97±0.93 [b]	18.27±0.63 [c]
1:1 W:O	48.87±1.80 [b]	10.66±0.98 [a]	19.32±0.53 [b]
1:3 W:O	37.29±4.05 [c]	9.85±1.66 [a]	20.92±1.07 [a]
Breading			
Control	50.31±4.79 [a]	8.36±1.48 [a]	19.56±1.25 [a]
3:1 C:O	48.94±7.30 [a]	8.41±1.37 [a]	20.21±1.42 [a]
1:1 C:O	46.08±7.92 [a]	9.74±1.89 [a]	19.26±1.21 [a]
1:3 C:O	45.56±7.42 [a]	10.22±1.73 [a]	19.22±0.74 [a]

W: wheat flour, O: oat flour, C: corn flour, The alphabets a, b and c in superscripts are the statistical differences among the samples.

Color Values of Fried Chicken Meat Balls

The effect of flour mixes on the color of fried chicken meat balls was determined in terms of *L*, *a*, and *b*. Flour mixes in battering had a significant ($p < 0.01$) effect on *L*, *a*, and *b* values, while in breading, it had a marginal ($p>0.05$) effect. *L* value decreased and *a* and *b* values increased after frying, while O in batter mixes increased (Table 4). The lowest *L* value was found in samples coated with 1:3 W: O as 37.29 in batters. The highest *a* values were observed in samples coated with 1:1 and 1:3 W: O as 10.66 and 9.85. However, the highest *b* value was found in samples coated with 1:3 W: O as 20.92 in batters. *L*, *a*, and *b* values were found in the ranges of 45.55–50.31, 8.35–10.22, and 19.22-20.21 for breading processes, respectively (Table 4).

The colour attributes of fried chicken meat products can increase preferential ability of the product visually. They affect consumer preference by increasing the attractiveness of the food. Batters with 1:3 W: O provide the darkest and the reddest colored chicken meat balls. This could be related to the high amount of protein in O. In addition, Maillard reactions also could be affected by color values during frying (Dogan et al. 2005). However, 1:3 W: O added batters have the highest yellowness compared with other mixes. These could be related to the high amount of carotenoid pigment in O compared with the W (Yılmaz & Dağlıoğlu, 2003). Colour values also showed that when O was added to the batter formulation, a significantly higher color development such as golden red was observed than in the case of W for fried chicken meat balls.

Sensory Properties of Fried Chicken Meat Balls

Sensory properties are very important factors for the food sector. They have a great impact on consumer choice, for example, color values. In this study, flour mixes did not have an effect on sensory properties and overall acceptability of fried samples for the battering process ($p > 0.05$), while they had an effect on the level of $p < 0.01$ on appearance, $p < 0.05$ on color, taste, and overall acceptability values for breading. Appearance, color, odor, taste, texture, and overall acceptability scores were found in the range of 5.68–6.68, 6.14–6.56, 5.86–6.34, 6.36–6.62, 6.08–6.65, and 6.13–6.57 for battering applications, respectively. In breading applications, all the mixes that had oat flour had a higher appearance, color, taste, and overall acceptability than the control, which had 5.27, 5.63, 5.98, and 5.76 mean scores (Table 5, Fig. 2).

Results showed that the appearance, color, and taste scores increased when O was added in breading mixes. This might be related with the protein and color pigment of O. However, protein degradation strengthened the structure of coating as well as improved the taste and juicy-crunchy structure of coated chicken meat balls. In addition, it supported color values along with carotene during frying.

Proteins and carotene pigments caused a blister, no crack surface, and a golden-yellow colour that was indicated as being very nice by the judges, a high chewing quality, and the unique taste of frying. The sensory results were similar to the results in the literature related to coating materials such as flour or their mixtures (Kulp & Loewe, 1990; Usawakesmanee et al. 2008; Kılınççeker & Kurt, 2010).

TABLE 5 EFFECTS OF COATING MATERIALS ON SENSORY PROPERTIES OF FRIED CHICKEN MEAT BALLS

Coatings	Appearance	Color	Odor	Taste	Texture
Battering					
Control	5.68±1.45 ^{a}	6.14±0.92 ^{a}	5.86±0.85 ^{a}	6.40±0.72 ^{a}	6.57±0.45 ^{a}
3:1 W:O	6.68±0.72 ^{a}	6.56±0.85 ^{a}	6.34±0.45 ^{a}	6.62±0.67 ^{a}	6.65±0.56 ^{a}
1:1 W:O	6.25±0.83 ^{a}	6.30±0.78 ^{a}	6.08±0.68 ^{a}	6.36±0.68 ^{a}	6.22±0.58 ^{a}
1:3 W:O	6.13±1.01 ^{a}	6.42±1.03 ^{a}	5.90±0.64 ^{a}	6.52±0.53 ^{a}	6.08±0.56 ^{a}
Breading					
Control	5.27±1.22 ^{b}	5.63±0.84 ^{b}	5.62±0.72 ^{a}	5.98±0.65 ^{b}	6.28±0.49 ^{a}
3:1 C:O	6.03±0.80 ^{ab}	6.29±0.88 ^{ab}	5.88±0.37 ^{a}	6.41±0.46 ^{ab}	6.43±0.43 ^{a}
1:1 C:O	6.78±0.66 ^{a}	6.81±0.70 ^{a}	6.41±0.58 ^{a}	6.65±0.52 ^{a}	6.57±0.48 ^{a}
1:3 C:O	6.66±0.57 ^{a}	6.67±0.64 ^{a}	6.26±0.72 ^{a}	6.84±0.62 ^{a}	6.23±0.83 ^{a}

W: wheat flour, O: oat flour, C: corn flour, The alphabets a, b and c in superscripts are the statistical differences among the samples.

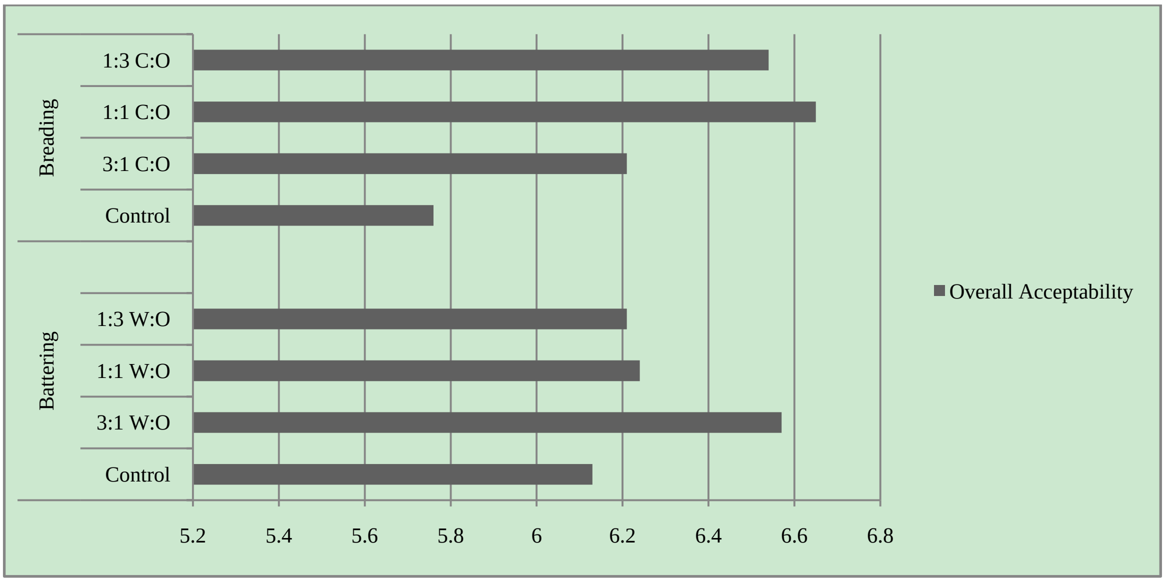

FIG. 2 EFFECTS OF COATING MATERIALS ON OVERALL ACCEPTABILITY VALUES OF FRIED CHICKEN MEAT BALLS

Conclusion

Oat flour in batter applications at the 1:1 W: O and 1:3 C: O could be effectively used as a functional ingredient in coated chicken meat balls by increasing adhesion, yield and decreasing cooking loss in samples. It could be also recommended to improve colour value in battered samples. However, oat flour has more advantages with regard to sensory properties than corn flour as the breading material. Thus, oat flour and its derivates that have different functional and nutritional properties can be used with wheat and corn flour in battering and breading formulations.

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